

Morphometric and Reproductive Parameters of the Prussian Carp (*Carassius gibelio*) of Lake Ullishurkul, Uzbekistan

Narboev Zokhid U.¹, Atamuratova Mukhayya Sh.², Quvatov Asqar Q.³, Tashbayeva Ugilshod A.⁴,
Aminova Dilnoza O.⁴, Isabaeva Mashkhura M.⁵

¹Urgench State University, Urgench

²Academy of Sciences of the Republic of Uzbekistan, Tashkent

³Alfraganus University, Tashkent

⁴Termez University of Economics and Service, Termez

⁵Kokand State University, Kokand

*Corresponding Author: a.quvatov@afu.uz; asqarquvatovxabb@mail.ru

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ABSTRACT

The article presents scientifically substantiated data on the ecological, morphometric and reproductive (individual development) traits and characteristics of the Prussian carp – *Carassius gibelio* (Bloch, 1782), common in Lake Ullishurkul. Data on the body length and weight of individuals were analyzed. No high variability was revealed in morphometric parameters (coefficient of variation $C_v = 12.39$). Age groups were also characterized based on the observation results. It was shown that the Fulton condition index and other parameters of the *Carassius gibelio* population correspond to the current biological conditions of the reservoir. The reproductive parameters of these fish were studied, including the relationship between individual absolute fecundity and body length and weight. It was found that in individuals aged 2+, the length fluctuates within the range of 160- 220mm, and weight is 150- 250g; in individuals aged 3+, the length reaches 190- 250mm, and the weight is 240-395g. The relationship between body length and weight on the T_{st} scale is high ($R^2 = 0.7985$), indicating general proportionality. As body length increases, the weight of individuals increases significantly. The regression equation $y = 0,0041 x^{2,0749}$ shows that the relationship is exponential with an exponent close to quadratic.

INTRODUCTION

Lake Ullishurkul is one of the largest natural lakes located in the Khorezm region of the Republic of Uzbekistan. It is located 14km southeast of the city of Khiva; its southern part extends into Turkmenistan and is located in the lower reaches. The total area of the lake is 14.8km², the elevation above sea level is 86m. Its length from north to south is 16km, and its width is 4km. The lake is fed primarily by collector and drainage waters, as well as wastewater from leaching fields in the north (Uzbekistan National Encyclopedia, 2005).

Currently, the northern parts of the lake are used for agricultural purposes. Artificial reservoirs have been created, and fish farms are underway. In the last 20-30 years of the last century, a number of ichthyological studies were conducted in natural reservoirs of the Khorezm region, focusing on the economic importance of fish species and their status in the wild (Khakberdiev, 1983).

The Prussian carp (*Carassius gibelio*) (Bloch, 1782) belongs to the Cyprinidae family (Cyprinids). The species is found primarily in rivers, lakes, reservoirs, canals, and ponds, preferring turbid waters. Over the past centuries, it has become widespread across Eurasia, from France and Spain to the Far East; it was accidentally introduced to North America (**Berg, 1948; Elgin *et al.*, 2014**). Its high ecological plasticity and significant reproductive capacity ensure its dominance in virtually all types of freshwater ecosystems worldwide (**Luskova, 2010**).

In Uzbekistan, the Prussian carp is common in all water bodies. It is of commercial importance and is a target for commercial fishing. Assessing the status of fish populations, particularly commercial species, is based on studying the age and growth rates of individuals within a given population (**Kamilova, 2021**).

From 1966 to 1970, large-scale ichthyological studies were conducted in lakes located in the southeast and southwest of the Khorezm region. The study focused on the ichthyofauna of Lake Ullishurkul, including the morphological and ecological characteristics of fish (age, growth rates), and the food supply of the lake's species. The reproductive characteristics and fecundity of commercially important fish were determined. Species acclimatized to the lake were also subjected to comprehensive analysis. Among these, the Prussian carp is one of the acclimatized species and is a widespread, primary commercial prey in Lake Ullishurkul. Previous studies provided detailed scientific data on the morphometric characteristics and reproductive biology of economically valuable commercial fish species (**Khakberdiyev, 1994**).

However, many years have passed since the aforementioned scientific studies, and today there is a need to resume the study of fish species. Eminently, as a result of modern climate and anthropogenic impacts, Lake Ullishurkul has also experienced a certain deterioration of the ecosystem.

Despite the research conducted, the study of bioecological indicators of fish species common in Lake Ullishurkul remains one of the pressing issues of our time.

Lake Ullishurkul was once a natural lake of great importance for fisheries. Today, the potential for fish farming is declining due to the decrease in water content of Lake Ullishurkul and the increase in salinity. Scientific research is being conducted on Lake Ullishurkul as part of the state program for the development of fisheries.

MATERIALS AND METHODS

The research material consisted of 24 fish specimens obtained during test catches in April 2025 in Lake Ullishurkul. The collection of the specimens, as well as the determination of morphometric and morphological parameters, were carried out according to generally accepted ichthyological methods (**Pravdin, 1966**). The classification of **Berg (1948)** and the fish identification guide proposed by scientists of the Republic (**Mirabdullayev *et al.*, 2011**) were used for species identification. During the studies, the length (mm) and weight (g) of the fish were measured, and their morphometric characteristics were determined. For statistical analysis of the morphometric parameters, the limits of variation (*Lim*), mean (*M*) and error of the mean (*m*), standard deviation (σ), coefficient of variation (*Cv*, %), and differences between characteristics were calculated (**Lakin, 1990**).

**Morphometric and Reproductive Parameters of the Prussian Carp (*Carassius gibelio*)
of Lake Ullishurkul, Uzbekistan**

Studies on sexual maturation and reproductive biology in fish were conducted using generally accepted methods (Sakun, 1968; Spanovskaya, 1976). Fecundity was determined using stage IV eggs collected from female fish (Spanovskaya, 1976).

In the area where the research was conducted, fish sampling locations were designated, coordinate points were indicated, and a geoinformation map was compiled (Table 1 & Fig. 1).

Table 1. Coordinates of collection sites for Prussian carp samples

Species name	Sampling location	Location coordinates
<i>Carassius gibelio</i>	Lake Ullishurkul	41°16'38.29"N 60°29'04.24"E
		41°16'35.75"N 60°28'57.49"E
		41°16'34.16"N 60°29'03.68"E
		41°16'33.37"N 60°29'00.65"E
		41°16'31.94"N 60°28'56.15"E

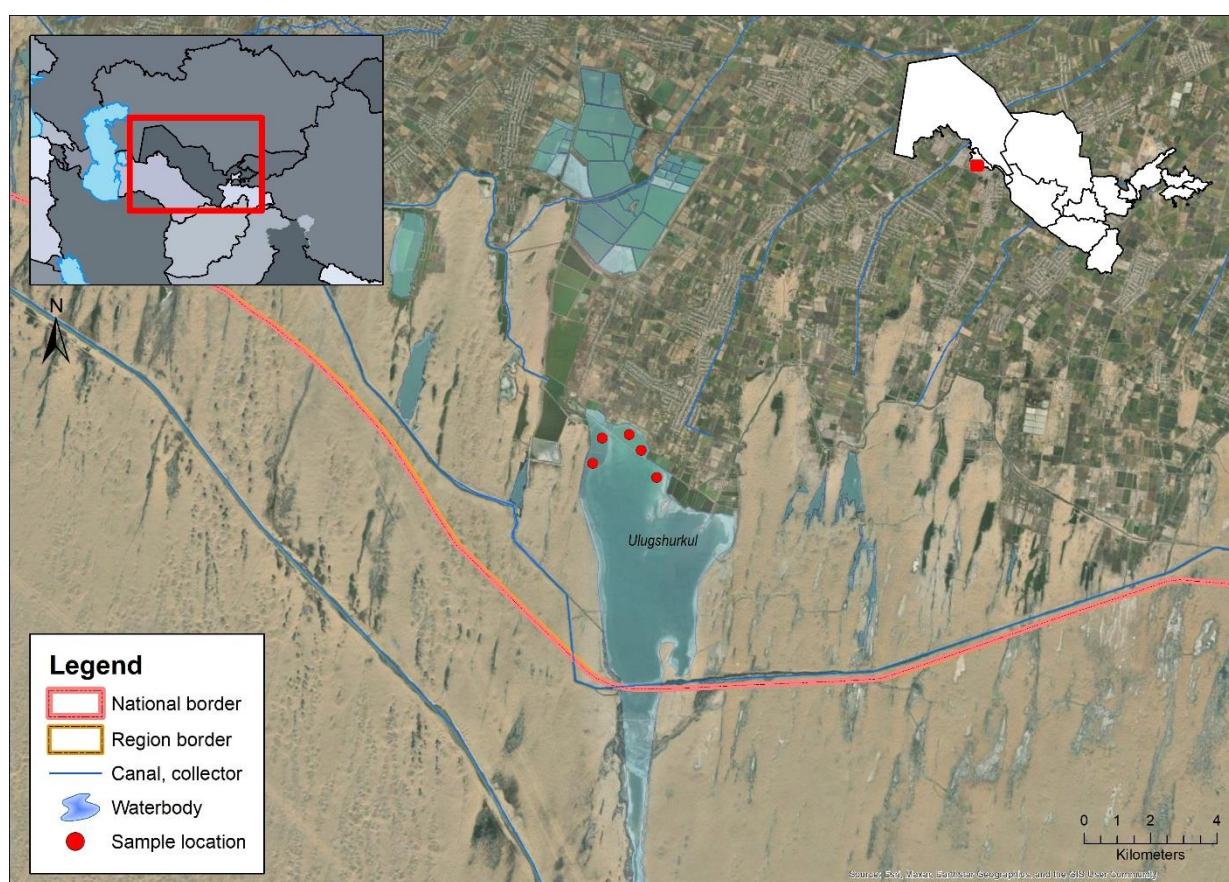


Fig. 1. General image of Lake Ullishurkul, located in the Khorezm region (Republic of Uzbekistan), indicating the points at which fish samples were collected

Based on the specified coordinates, an analysis of the collected data was performed, the age of the caught Prussian carp was determined, the length and body weight were measured, and their reproductive capacity was assessed - all these data served as an important basis for the subsequent interpretation of the results.

RESULTS AND DISCUSSIONS

The morphometric parameters of the studied fish were analyzed statistically (Table 2). The standard body length was $240.25 \pm 6.07\text{mm}$, with total body length being identified as the most significant baseline parameter. Body height (h) was $53.40 \pm 1.14\text{mm}$, accounting for approximately 22% of body length.

The parameters related to head length were also analyzed. The eye diameter (ao/c) was $6.26 \pm 0.16\%$, the distance from the eye to the occipital part of the head (po/c) was $27.12 \pm 0.33\%$, and the interorbital distance (io/c) was $12.52 \pm 0.57\%$. These ratios reflect the stability of head morphology.

The values of the variation coefficient ($Cv=5-15\%$) indicate that the morphometric characteristics are quite stable both genetically and ecologically (Table 2).

Table 2. Morphometric parameters of Prussian carp from Lake Ullishurkul
($n = 24$)

Signs	Lim.	$M \pm m$	Σ	S^2	Cv %
As a percentage of body length (l)					
l, mm	189.0±291.0	240.25±6.07	29.76	885.67	12.39
c	76.92±85.78	81.02±0.39	1.92	3.70	2.37
ao	4.00±6.22	5.07±0.13	0.65	0.43	12.88
o	3.44±4.57	3.88±0.06	0.29	0.08	7.50
po	9.50±12.18	10.72±0.12	0.60	0.36	5.57
hc	18.10±21.83	19.96±0.21	1.03	1.05	5.14
io	7.24±9.48	8.53±0.11	0.52	0.27	6.11
H	27.15±39.11	32.12±0.54	2.67	7.13	8.31
H	11.68±14.67	12.93±0.14	0.70	0.49	5.40
aD	34.91±40.95	38.64±0.31	1.53	2.33	3.95
pD	9.57±16.81	13.57±0.33	1.61	2.58	11.83
Pl	9.52±12.22	11.27±0.17	0.83	0.68	7.33
lD	26.86±34.67	31.79±0.43	2.12	4.49	6.67
HD	12.01±16.75	14.25±0.23	1.13	1.28	7.95
lA	8.60±11.21	10.11±0.15	0.73	0.54	7.24
hA	10.31±14.72	12.67±0.26	1.27	1.60	10.00
lP	15.38±22.58	18.44±0.30	1.46	2.13	7.92
IV	13.33±18.18	15.31±0.23	1.14	1.29	7.42
PV	12.82±19.91	15.09±0.39	1.92	3.70	12.75
VA	21.74±27.56	25.08±0.33	1.60	2.57	6.39
As a percentage of head length (c)					
ao/c	4.84±7.69	6.26±0.16	0.80	0.65	12.84

**Morphometric and Reproductive Parameters of the Prussian Carp (*Carassius gibelio*)
of Lake Ullishurkul, Uzbekistan**

<i>o/c</i>	4.33±5.81	4.79±0.08	0.39	0.15	8.15
<i>po/c</i>	12.16±15.48	13.23±0.15	0.73	0.54	5.55
<i>hc/c</i>	22.97±27.74	24.64±0.27	1.32	1.75	5.36
<i>io/c</i>	9.15±11.35	10.52±0.12	0.57	0.32	5.38

Overall, the obtained results confirm that in the studied population the proportions of body length and head length are characteristic, mutually consistent and stable.

Body length and weight data were analyzed for Prussian carp samples from the Ullishurkul reservoir. Observations revealed the following reproductive characteristics for age groups: 2+ specimens ranged in length from 160 to 220mm and weighed 150 to 250g; 3+ specimens ranged in length from 190 to 250mm and weighed 240 to 395g.

Overall, the obtained results show that the proportions of body length and head length in the studied fish population are specific and confirm their mutual consistency and stability.

Body length and weight data were analyzed for the analyzed specimens of Prussian carp from the Ullishurkul reservoir. The following age-related and reproductive characteristics were established: for individuals in age group 2+, body length ranged from 160-220 mm, and weight was 150-250 g; for individuals in age group 3+, body length reached 190-250 mm, and weight was 240-395 g.

The relationship between body length and weight is highly correlated ($R^2 = 0.79$), indicating a significant increase in weight with increasing body length. This suggests that weight gain in fish increases more rapidly as they grow (Fig. 2).

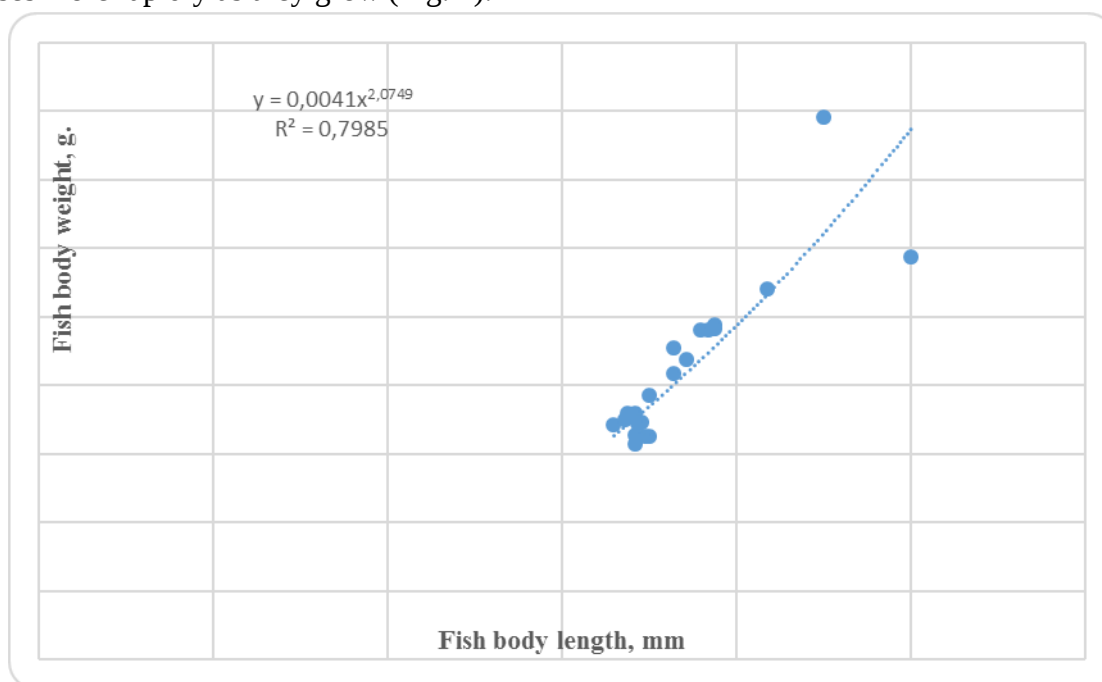


Fig. 2. Relationship between body length and weight of Prussian carp (according to the Fulton index)

The Fulton index and other indicators also confirm that the species population has a sufficient food supply and that biological growth occurs in accordance with natural environmental conditions.

The spawning period of the Prussian carp lasts from April to June (**Mirabdullaev et al., 2020**). As a result of the research, caviar was collected for the first time in April (03.04.2025). Carp aged 2+, 3+, and 4+ caught in Lake Ullishurkul were analyzed (Table 3).

Table 3. Reproductive characteristics of female Prussian carp of age groups 2+, 3+ and 4+ caught in Lake Ullishurkul

<i>T</i>	<i>l, sm</i>	<i>W, gr</i>	<i>IMS, pcs</i>	<i>INS, pcs</i>	<i>n</i>
2+	<u>17.1-18.4</u>	<u>114-176</u>	<u>17360-23124</u>	<u>152.2-131.3</u>	2
	17.7	145	20242	141.7	
3+	<u>18.9-22.1</u>	<u>204-318</u>	<u>28203-53904</u>	<u>138.2-169.5</u>	8
	20.5	261	41053.5	153.8	
4+	<u>23.9-26.5</u>	<u>326-427</u>	<u>49495-64285</u>	<u>151.8-150.5</u>	3
	25.2	376.5	56890	151.1	

Note. In the Table: the numerator shows the limits, the denominator – the average values. In addition: *l*, cm – body length; *W*, g – body weight in grams; *IMS* – individual absolute fecundity; *INS* – individual relative fecundity; *n* – the number of individuals studied.

The results show that the body length and weight of the studied goldfish specimens increased with age. Concurrently, the overall fecundity (*IMS*) also increased significantly from age 2+ to age 4+, indicating increased reproductive potential in older individuals. Individual relative fecundity (*INS*) remained virtually stable across all age groups, with only minor fluctuations. This indicates that the number of eggs per gram of body weight does not undergo significant age-related changes.

Individual absolute fecundity (*IMS*) values were also analyzed depending on the age of the Prussian carp (Fig. 3). The graph shows that *IMS* values consistently increase with age.

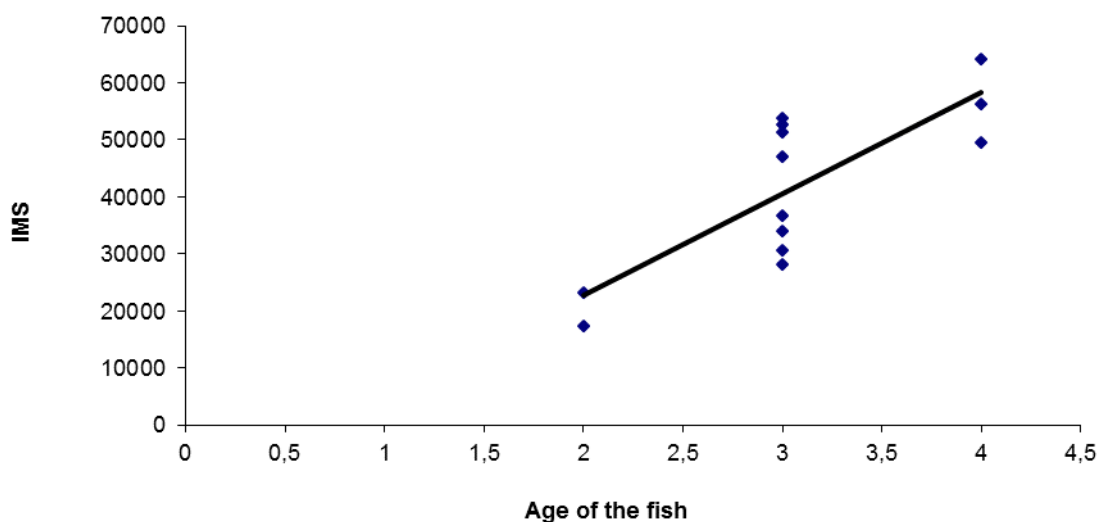


Fig. 3. The relationship between age and individual absolute fertility of Prussian carp specimens caught in Lake Ullishurkul

Morphometric and Reproductive Parameters of the Prussian Carp (*Carassius gibelio*) of Lake Ullishurkul, Uzbekistan

In two-year-old specimens, IMS values were relatively low (17.000-23.000 eggs), while in three-year-old specimens, they were significantly higher (28.000-53.000 eggs), and in four-year-old specimens, the highest values were recorded (49.000-64.000 eggs). The scatter of points on the graph indicates individual differences within age groups, meaning that even in fish of the same age, IMS can vary significantly.

The relationship between individual absolute fecundity of Prussian carp and body length and weight was also studied. The graph shows that IMS values increase sharply with increasing body length. Individual absolute fecundity also increased consistently with increasing age (Fig. 4).

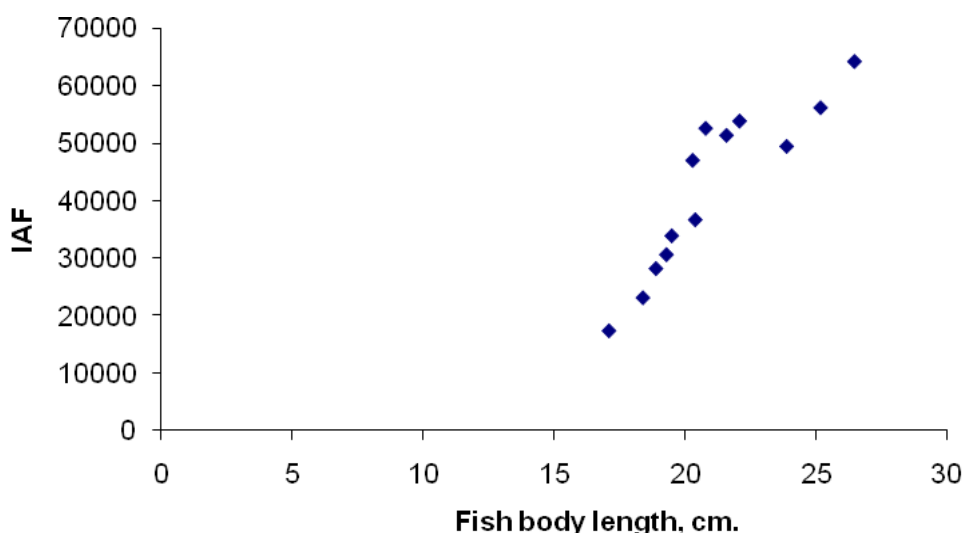


Fig. 4. The relationship between individual absolute fertility and body length of Prussian carp caught from Lake Ullishurkul

The study results show that individual fecundity (IMS) consistently increases with increasing body length in the analyzed fish. According to graphical analysis, in fish 17-18 cm long, IMS ranged from 17.000 to 20.000 eggs, while in individuals reaching 25- 26cm in length; this value exceeded 60.000 eggs. This indicates a strong positive correlation between body length and fecundity.

Regression analysis confirmed the high correlation between IMS and body length. The linear model yielded a coefficient of determination of $R^2 = 0.56$, the exponential model yielded an $R^2 = 0.74$, while the polynomial model demonstrated the highest accuracy, reaching an $R^2 = 0.769$ (Fig. 5).

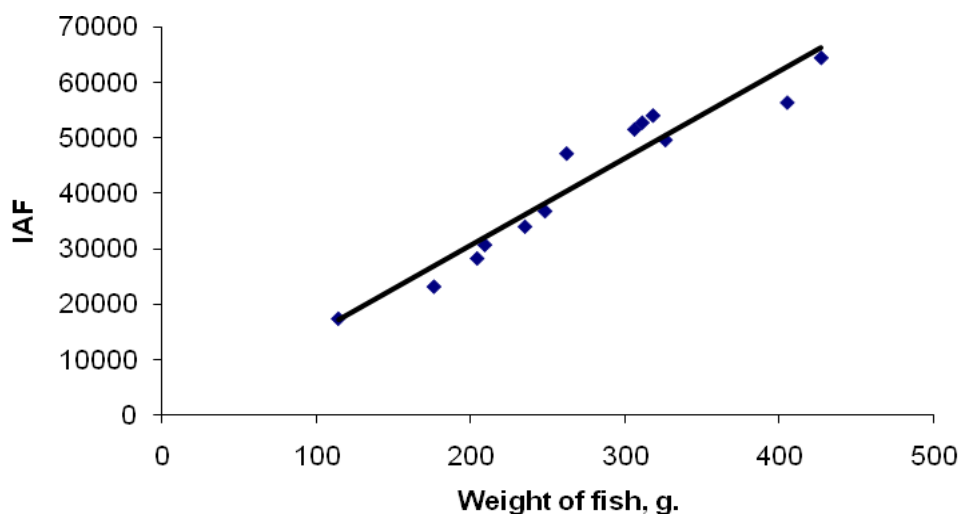


Fig. 5. The relationship between body weight and individual absolute fertility of Prussian carp caught from Lake Ullishurkul

Individual maximum fecundity (IMS) ranged from 17,360 to 64,285 eggs, with an average of 40,822 eggs. The data points on the diagram represent the relationship between fish weight and fecundity. The data presented demonstrates that individual absolute fecundity (IMS) increases with increasing fish body weight.

CONCLUSION

Thus, the body and head proportions of the studied fish are proportionate and stable, reflecting species-specific morphological characteristics. The fact that the head length is approximately $\approx 19\%$ of the body length and the relatively small eye diameter indicates the ecological adaptability of the fish and the functional specificity of their sensory organs. Low values of the coefficient of variation ($Cv = 5-15\%$) indicate the stability of morphometric traits within the population.

A significant positive correlation was found between the body length and weight of Prussian carp ($R^2 = 0.79$). Consequently, in the Prussian carp population inhabiting the Ullishurkul reservoir, an increase in body length is accompanied by a significant increase in weight. This reflects the availability of an adequate food supply, favorable environmental conditions for biological growth, and confirms the normal course of the population's natural development.

The obtained results confirm that the goldfish population in Lake Ullishurkul has a high reproductive potential, with fish in age groups 3+ and 4+ playing a key role in the reproduction process. This is an important factor ensuring rapid population growth and its sustainable existence in the natural environment.

Furthermore, a direct correlation has been established between body length and reproductive potential in Prussian carp. A positive relationship has also been observed between individual weight and their absolute fertility: according to statistical analysis, fertility increases proportionally with increasing body weight. This, in turn, indicates that larger individuals have higher reproductive potential.

GRATITUDE

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AUTHORS' CONTRIBUTIONS

Collection of scientific material, recording, office processing and analysis were carried out by Z.U. Narboev, preparation of the article A.Q. Quvatov and all practical processes were carried out by the other authors.

CONFLICT OF INTEREST

There were no conflicts between the authors on the collection, sorting, cameral processing, and distribution of the materials.

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